International Journal of Bio-Technology and Research (IJBTR)
ISSN(P): 2249-6858; ISSN(E): 2249-796X
Vol. 5, Issue 4, Aug 2015, 27-36

EXPERIMENTAL INVESTIGATIONS ON THE PERFORMANCE AND EXHAUST EMISSIONS OF A DIESEL ENGINE USING JATROPHA OIL AS A FUEL

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ABSTRACT

Efforts are under way in many countries, including India, to search for suitable alternative fuels for diesel that are environment friendly. The need to search for an alternate fuel arises mainly from the standpoint of preserving the global environment and the concern about long term supplies of conventional hydrocarbon- based diesel fuels. Bio-diesel is a domestically produced, renewable fuel that can be used in unmodified diesel engines with the current fuelling infrastructure. It is safe, biodegradable and reduces serious air pollutants such as soot, particulates, carbon monoxide, hydrocarbons, and air toxics. Performance, storage requirements and maintenance are similar to bio-diesel blend fuels and petroleum diesel. In India, Jatropha is found to have favourable agricultural conditions for growth. Its advent is going to prove very beneficial for the Indian as well as the world market even as fossil fuel's demand goes on increasing i.e., indirectly proportional to its availability. In this work, Bio-diesel I have produced from Jatropha oil by a chemical process called Transesterification process. Bio-diesel is blended with the Diesel fuel in various ratios and also used as a sole fuel in a single cylinder diesel engine. The performance and emission characteristics are studied. In this project work the suitability of bio-diesel as a better alternative fuel for diesel engine is investigated and established.

KEYWORDS: Experimental Investigations, Bio-diesel, Jatropha Oil

INTRODUCTION

Two main areas of concern to man are pollution control and the discovery of renewable energy sources. The conservation of vegetable into oil diesel fuel combines both these. The use of vegetable oil as fuel for diesel engines is not a new concept. Since the invention of the diesel engine, subsequent developments of this engine has been based on the availability of petroleum-derived diesel fuel, which in turn has been tailored to meet the needs of the current engines. Due to the availability of the more economic petroleum-derived diesel, the use of vegetable oils as fuels did not come into the limelight. The use of vegetable oils as fuel depends on the world market prices for mineral products and is therefore of special interest, at present, only for those countries with excess oil production. At times of acute energy shortage, such as during World War II in Europe, vegetable oils have been used as fuel, either neat or in blends with diesel fuels. However, the fuels gave rise to excessive carbonaceous deposits on the cylinders and on the injector nozzles. Basically, three theories have been postulated to explain the various durability problems that have been observed in the engines run with vegetable oil. They are:

- The high viscosity of vegetable oils results in degraded fuel atomization which in turn results in the observed durability problems.
- The durability problems associated with the use of vegetable oil fuels result directly from the chemical structure of the oils and the effect of structure on the combustion chemistry.
- The durability problems are the result of the incomplete combustion of the fuels, the subsequent reaction of the fuels and partial combustion products on the metal surfaces and in the lubricating oil.
- Although some evidences exists that fuel chemistry affects durability problems, the majority of the evidence indicates that the high viscosity of the oils is the major factor controlling the onset and severity of the durability problems. One way of tackling the problem is to reduce the viscosity of the fuel. This can be done by
- Adding viscosity depressants.
- Forming micro-emulsions of vegetable oils with alcohol and diesel. One such micro-emulsion is a blend of oil with diesel and ethanol.
- Heating the oils prior to injection into the engines.
- By forming blends with low viscosity fuels. Such blends have been named as hybrid fuels.
- Transesterification of the glyceride.

This project work concentrates on the use of Transesterified vegetable oil, i.e., Bio-diesel, in diesel engine, i.e., to conduct short-term engine tests on a diesel engine using bio-diesel and also petroleum diesel and to compare the performance and emission characteristics.

BIO DIESEL

Bio-diesel has defined as the monoalkyl esters of long chain fatty acids derived from renewable feed stocks, such as vegetable oil or animal fats, for use in diesel engines. Bio-diesel is commonly composed of fatty acid methyl esters (FAME) that are prepared from the triglycerides in vegetables oil by transesterification with methanol. Bio-diesels contain on petrol, but it can be blended with petroleum or diesel products at any level to create Bio-diesel blend. It can be used in compression ignition engines with no modification. Bio-diesel is simple to use non toxic and essentially free from sulphur and aromatics.

WHY BIO-DIESEL?

- Cost effective
- Sustainable
- Safety in handling
- Eco-friendly
- Renewable
- Reduces our depend on foreign petroleum

- Helps for effective utilization of waste lands
- Generates employment in rural sector & enriches rural economy
- Weather resistance
- Clean development mechanism
- Fixes atmospheric carbon dioxide
- Less acid rain
- Effective in management

PARAMETERS DECIDING SUITABILITY AS BIO FUEL

- Local availability
- Nearness in properties to diesel including calorific value
- Suitability of using them in present diesel engine without much modification
- Desirable exhaust emission characteristics
- Capability to produce the resource cheaply without competing with other agricultural and forest based demands on land, water and other investments.
- Carbon management
- Generation of extra value added products there from.

PREPARATION OF BIO-DIESEL

Bio-diesel is produced form the vegetable oil by a chemical process called transesterification process. It is the process in which the vegetable oil is treated with alcohol in the presence of a catalyst to form ester and glycerol. This method has been used to reduce the viscosity of the vegetable oil.

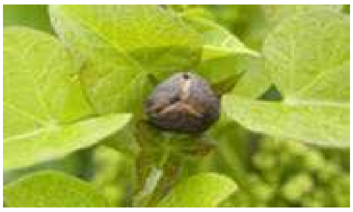


Figure 1

The vegetable oil used in the project work is *JATROPHA CURCAS OIL* and the alcohol used is methanol. Sodium hydroxide is used as catalyst. The catalyst is first added to the alcohol and dissolved in the alcohol by stirring. The solution is mixed with the jetrophaoil . the content after mixing thoroughly are heated to temperature of about 55degree and is maintained at the temperature of about 3 hours with constant stirrings at regular intervals. Then it is allowed to settle down for 10 to 12 hours. The denser glycerine and soaps settle down and are darken in colour. The methyl esters lighter in colour are separated. The colour difference between the two layers will enable their easy separation. The soap present in the methyl ester layer are removed by washing the ester with distilled water. After washing they are allowed to settle down for

3 to 5 hours. With their different densities water is removed and pure methyl is obtained and called BIO-DIESEL.

JATROPHA CURCAS

Jatropha curcas, a shrub or small tree, is planted in tropical and sub tropical countries as a living fence to protect gardens and fields from animals. It produces small seeds which contain more than 30% of non edible oil.

- It needs minimal inputs or management
- It has no insects, pests and not browsed by cattle or sheep
- Can survive long periods of drought
- Propagation is easy
- It starts yielding from the 3rd year onwards and contains for 25 to 30 years
- The meal after extraction of oil from the seeds can used as excellent organic manure

The extracted, esterified oil can be used in diesel engines directly or blended with diesel as the properties of the oil matches with that of the diesel and offers various advantages when compared with diesel.

THE YIELD FACTOR

Under normal conditions, jatropha cultivation gives a yield of 2 tones per hectare. This yield of seeds would yield 25-30 percent of oil. That is 100Kg of jatropha yield 25-30 kg of jatropha oil.

THE COST FACTOR

Table 1

EXPENSES		
price of the seed	=	Rs.7.00 per Kg
4 kg feed	=	1 kg oil (1150ml)
For 4 Kg of seed	=	Rs.28.00
Grinding, dehulling, crushing	=	Rs.4.00
Total	**=**	**32.00**
BENEFITS		
2.5 kg of cake for manure sold at Rs.4.00 per Kg	=	Rs.10.00
Shell is sold at	=	Rs.2.00
Net price of 1Kg of oil	=	Rs.32-Rs.12
	=	**Rs.20.00**

After carrying out the esterification process, the cost of one litre of Bio-diesel will increase. The by-products such as glycerol can be used in soap making and cosmetics. This would reduce the net cost of the Bio-diesel. If mass production is carried out, the cost of the Bio-diesel can be reduced to a considerable amount.

- **Density/ Specific Gravity**

The bio-diesel produced is slightly heaver than the conventional diesel fuel. This allows splash blending by adding bio-diesel on top of diesel fuel for making bio-diesel blend. Bio-diesel should always blended at the top of diesel fuel. If bio-diesel is put at the bottom and then diesel fuel is added , it will not mix.

- **Viscosity**

Viscosity of bio-diesel is higher than that of diesel fuel. So, when it is used in engines, this may lead to gum formation on injectors, cylinder liner etc. but, when compared to jatropha oil, the viscosity of bio-diesel is ten times lesser.

- **Flash Point**

The flash point of bio-diesel is high. So, its blending with diesel fuel can utilized in increase the flash point of diesel fuel, particularly in India flash point is around 40 ºC which is well bellow the world average of 55 ºC. This important from the safety point of view.

- **Heat of Combustion**

The heat of combustion of bio-diesel is slightly lower than the diesel fuel.

- **Cetane number**

Bio-diesel produced has higher cetane number than diesel fuel. This results in higher combustion efficiency and smoother combustion

EXPERIMENTAL INVESTIGATION

Short-term engine tests were performed on kirloskar single cylinder diesel engine and on texvel single cylinder diesel engine with diesel, bio-diesel, diesel & bio-diesel blends. Performance and emission character are studied.

The test are carried out with,

- Pure diesel
- 95% diesel + 5% bio-diesel(B5)
- 85% of diesel +15% bio-diesel(B15)
- 75% o diesel +25% of bio-diesel(B25)

The engine details, apparatus required and experimental procedures are given bellow.

ENGINE SPECIFICATION

- **Texvel Engine**

Table 2

Type	-	Single Cylinder, Vertical, Four Stroke Cycle, Water Cooled, Compression Ignition Diesel Engine
Bore in mm	-	80
Stroke in mm	-	110
Rated rpm	-	1500
Rated power out put in KW	-	6.55
Loading type	-	Rope braking

- **Apparatus Required**

Stop clock used to find the time required for the consumption of 10cc of fuel, hand tachometer to measure the speed of the engine, KANE-MAY (KM-900) combustion analyzer and MAESTER 2000- exhaust gas analyzer to measure the exhaust gas emissions such as CO and NOx.

- **Precautions**

The following precaution was taken before starting and after the end of the experiment.

Before starting, the fuel supply and the lubricant oil level were checked. Starting auxiliaries were checked and engine was ensured to be on no load. The crank key is removed carefully after the engine was started. The engine is made to run at rated speed. At the end of the experiment all the loads are gradually removed from the engine and after stopping fuel oil supply is closed from the service tank.

- **Formula Used**

- Brake power = (2πNW Re)/ ($60*10^3$) in KW

Where W- Load applied in Newton.

- Total fuel consumption (TFC) = (X*3600*0.833)/ (t*1000) in Kg/hr

Where t- Time taken for 25 ml fuel consumption

Specific gravity of diesel = 0.833.

- Specific fuel consumption (SFC) = TFC/B.P in Kg/ KW-hr
- Indicated power (I.P) = B.P + F.P in KW
- Mechanical efficiency (ηmech) = B.P/I.P in %

TEST PROCEDURE

The standard test procedure with all precautions was used and performance test was carried out. The times taken for the consumption of 25 cc of fuel and exhaust emission values are noted.

The brake power, total fuel consumption, specific fuel consumption, indicated power mechanical efficiency is calculated from the observed values.

CONVENTIONAL DIESEL

Table 3: Performance Data and Emission Data

Sl. No	Speed (N) RPM	Applied Load (Kg)	Time Taken for 25 Cc Fuel Consumption in Sec	TFC (Kg/Hr)	Brake Power K.W	S.F.C (Kg/Kwhr)	I.P (Kw)	ηMech (%)	Nox (Ppm)	CO %
1	1100	5	192.00	0.3900	1.7540	0.2220	4.2540	41.23	1420	0.14
2	1100	10	162.00	0.4620	3.5090	0.1310	6.0090	58.39	1920	0.12
3	1100	15	138.00	0.5430	5.2630	0.1030	7.7640	67.78	2160	0.11
4	1300	5	172.00	0.4350	2.0730	0.2090	4.5730	44.56	1460	0.13
5	1300	10	138.00	0.5430	4.1470	0.1300	6.6470	62.38	1580	0.11
6	1300	15	112.00	0.6690	6.2200	0.1070	8.7200	71.33	2020	0.10

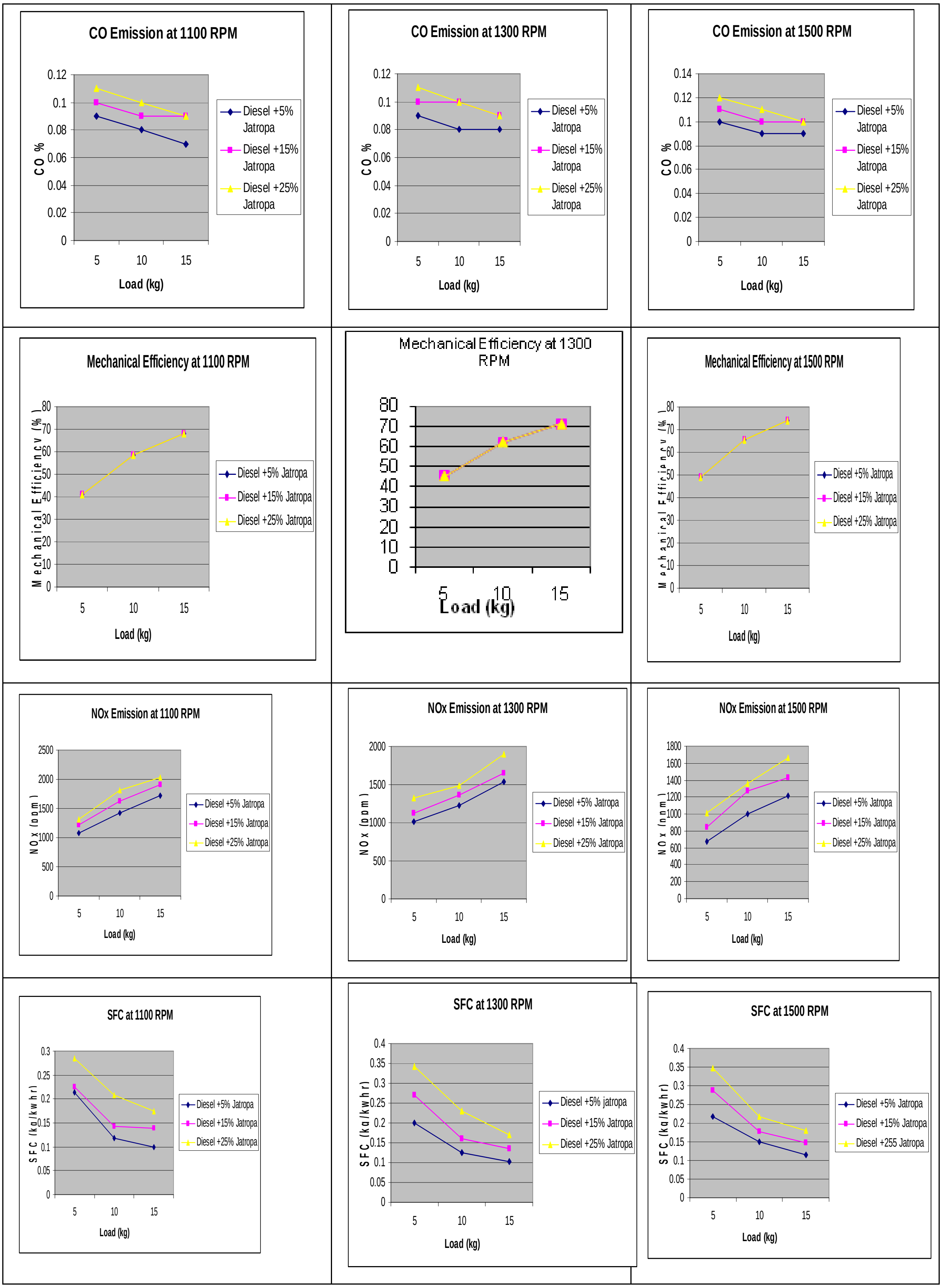
Table 4: Contd.,										
7	1500	5	138.00	0.543	2.3920	0.2270	4.8920	48.89	1200	0.14
8	1500	10	102.00	0.7350	4.7850	0.1530	7.2850	69.68	1560	0.13
9	1500	15	78.00	0.9610	7.1780	0.1330	9.6780	74.16	1780	0.11

BIO-DIESEL

Table 5

At 1100 Rpm Performance Tabulation For Diesel + 5% Jatropha Oil									
Sl. No	**Applied Load (Kg)**	**Time Taken for 25 Cc Fuel Consumption in Sec**	**TFC (Kg/Hr)**	**Brake Power K.W**	**S.F.C (Kg/Kwhr)**	**I.P (Kw)**	**ηMech (%)**	**Nox (Ppm)**	**CO %**
1	5	200.00	0.3748	1.7546	0.2136	4.2140	41.20	1084	0.09
2	10	180.00	0.4165	3.5092	0.1186	6.0090	58.30	1420	0.08
3	15	144.00	0.5206	5.2638	0.0989	7.7638	67.79	1718	0.07
At 1300 Rpm Performance Tabulation for Diesel + 5% Jatropha Oil									
Sl. No	**Applied Load (Kg)**	**Time Taken for 25 Cc Fuel Consumption in Sec**	**TFC (Kg/Hr)**	**Brake Power K.W**	**S.F.C (Kg/Kwhr)**	**I.P (Kw)**	**ηMech (%)**	**Nox (Ppm)**	**CO %**
1	5	180.00	0.4165	2.0736	0.2008	4.5736	45.33	1016	0.09
2	10	144.00	0.5206	4.1473	0.1255	6.6437	62.39	1228	0.08
3	15	116.12	0.6452	6.2209	0.1037	8.7209	71.33	1541	0.08
At 1500 Rpm Performance Tabulation for Diesel + 5% Jatropha Oil									
Sl.No	**Applied Load (Kg)**	**Time Taken for 25 Cc Fuel Consumption in Sec**	**TFC (Kg/Hr)**	**Brake Power K.W**	**S.F.C (Kg/Kwhr)**	**I.P (Kw)**	**ηMech (%)**	**Nox (Ppm)**	**CO %**
1	5	144.00	0.5206	2.3926	0.2175	4.8926	48.90	670	0.10
2	10	109.09	0.6872	4.7853	0.1496	7.2853	65.68	1002	0.09
3	15	90.00	0.8330	7.1780	0.1160	9.6780	74.16	1218	0.09
At 1100 Rpm Performance Tabulation for Diesel + 15% Jatropha Oil									
Sl. No	**Applied Load (Kg)**	**Time Taken for 25 Cc Fuel Consumption in Sec**	**TFC (Kg/Hr)**	**Brake Power K.W**	**S.F.C (Kg/Kwhr)**	**I.P (Kw)**	**ηMech (%)**	**Nox (Ppm)**	**CO %**
1	5	189.47	.3956	1.7546	.2254	4.2590	41.20	1221	.10
2	10	150	.4998	3.5092	.1424	6.0090	58.30	1625	.09
3	15	102.85	.7289	5.2638	.1384	7.7638	67.79	1900	.09
At 1300 Rpm Performance Tabulation for Diesel + 15% Jatropha Oil									
Sl. No	**Applied Load (Kg)**	**Time Taken for 25 Cc Fuel Consumption in Sec**	**TFC (Kg/Hr)**	**Brake Power K.W**	**S.F.C (Kg/Kwhr)**	**I.P (Kw)**	**ηMech (%)**	**Nox (Ppm)**	**CO %**
1	5	133.33	.5622	2.0736	.2711	4.5736	45.33	1130	.10
2	10	112.50	.6664	4.1473	.1606	6.6473	62.39	1365	.09
3	15	90	.8330	6.2209	.1339	8.7209	71.33	1650	.09
At 1500 Rpm Performance Tabulation for Diesel + 15% Jatropha Oil									
Sl. No	**Applied Load (Kg)**	**Time Taken for 25 Cc Fuel Consumption in Sec**	**TFC (Kg/Hr)**	**Brake Power K.W**	**S.F.C (Kg/Kwhr)**	**I.P (Kw)**	**ηMech (%)**	**Nox (Ppm)**	**CO %**
1	5	109.09	.6872	2.3926	.2872	4.8926	48.90	840	.11
2	10	87.80	.8538	4.7853	.1784	7.2853	65.68	1266	.10
3	15	70.58	1.0620	7.1780	.1479	9.6780	74.16	1433	.10

PERFORMANCE CURVES



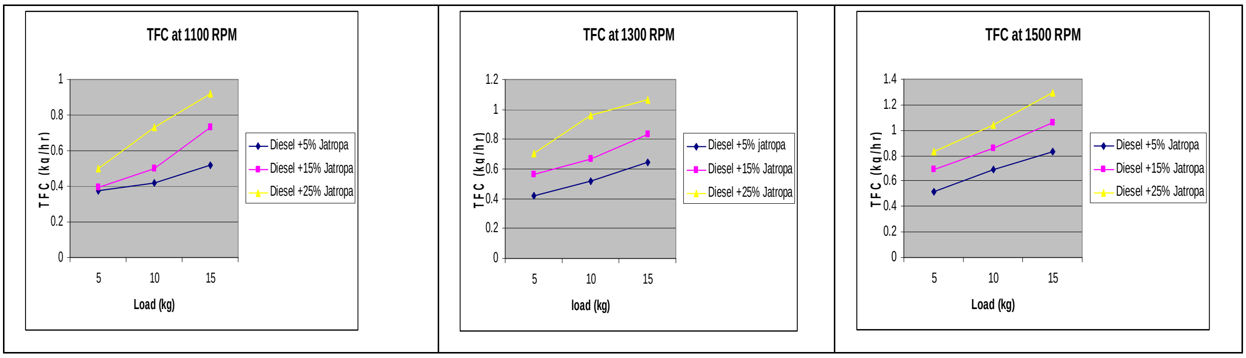


Figure 2

CONCLUSIONS

From the test conducted on the single cylinder Diesel Engine of the make TEXVEL, without any engine modification. The blend of 5%, 15% and 25% of Jatropha oil is recommended for the following reasons.

- High mechanical efficiency.
- Exhaust gases are well within the EURO 1 emission standard.
- There is no knocking of engine, hence no damage to the engine.
- There is around 10% to 20% cost effective than conventional diesel.

FURTHER SCOPE

- Test for longer periods can be conducted to access the impact on life of the engine.
- Engine modifications such as change in design of atomizer nozzle, using fuel pre-heater for pure oil can improve efficiency.
- Esterified oils can be used and tested for better results.
- Similar tests can be carried out on other vegetable oils such as Cotton seed oil, Soya beans oil, Drum stick oil,

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